Refine Cut Strategy

- Everything has been moved into the framework
  - Branch: TPrimeLeptonOS

- Focus on 1 signal process for now
  - T'->tH; t->Wb->qqb; H->WW->l+l-***vv*** (1 lepton pair, 3 jets and at least 1 b jet)

- Basic cuts
  - Cuts for muons
    - Tight ID cut: Muon_tightId
    - Pt(mu) > 20GeV
    - |eta| < 2.4
    - Tight isolation cut: goodMuons_miniPFRelIso_all < 0.05
  - Cuts for jets
    - Tight jet ID cut: Jet_jetId: 6
    - Pt(jet) > 30GeV
    - |eta| < 2.5
  - Cuts for events
    - 1 OS muon pair
    - At least 3 jets
    - At least 1 b jet
      - Loose b-tag jet: goodJets_btagDeepFlavB>0.049

Refine Cut Strategy

- Cuts to select case1 from all 3 processes in signal
  - deltaR(mu+, mu-) < 1 (This cut is got from GEN information study)
  - Not in Z mass window cut: mu pair mass∉[80, 100] (plot)
    - Should I replace Z mass wondow with Chi2 sorting algorithm?
      - Where to get mean and sigma of Z peak? (Signal MC or Dataset)

- Pt related cuts from Punzi optimization
  - mu pair pt > 140 (Sum as vector)
  - HT > 300 (Sum as scalar)

- Cut related to muons and b jet
  - deltaR(mu+, loose b jet) > 1.5 && deltaR(mu+, loose b jet) > 1.5

- Cuts from Jets reconstruction
- Remove this weird cut: ~~70 < non-b (medium) jet pair mass < 100~~
  - Apply Chi2 sorting algorithm in AN-21-140
    - Chi2 < 15 (maybe too big) Loose

$$\chi_w^2 = \frac{(M_W - M_{jj})^2}{\sigma_W^2}$$

$$\chi_{top}^2 = \frac{(M_t - M_{bjj})^2}{\sigma_t^2}$$

$$\chi^2 = \chi_w{}^2 + \chi_{top}{}^2$$

Chi2 Sorting Algorithm for Jets

- Apply Chi2 sorting algorithm described in AN-21-140 (line 210- 231)
  - Reconstruct top->Wb->qqb with 3 good jets
  - Loop on all selected jets, select two jets, make a W candidate and evaluate the Chi2_w part
  - Loop on all selected b-tag jets, reject the jets used for the W candidate, select one b-tag jet and combine it with the W candidate and evaluate the Chi2_top part. The sum of Chi2_w and Chi2_top is then minimised
  - Cut on Chi2 or Chi2_top

$$\chi^2_w = \frac{(M_W - M_{jj})^2}{\sigma^2_W}$$

$$\chi^2_{top} = \frac{(M_t - M_{bjj})^2}{\sigma^2_t}$$

$$\chi^2 = \chi w^2 + \chi top^2$$

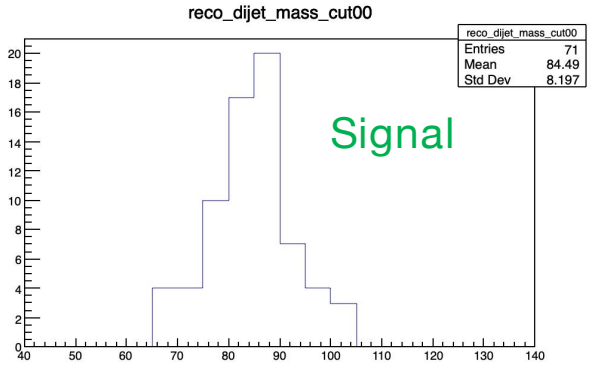
Table 1: Value of masses/σ used to build the χ^2 in the case of using the value from observed reconstructed masses in 2016, in 2017 UL and in 2018 UL.

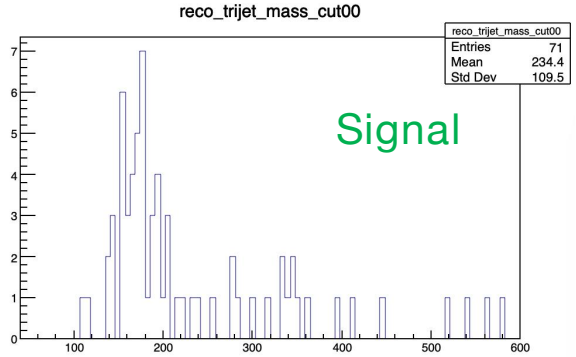
Particles	Reconstructed Masses			Reconstructed σ		
	2016	2017 UL	2018 UL	2016	2017 UL	2018 UL
M_Z	90.9 ± 0.4 GeV/c^2	89.2 ± 0.3 GeV/c^2	90.9 ± 0.3 GeV/c^2	11.4 ± 0.4 GeV/c^2	12.0 ± 0.3 GeV/c^2	11.3 ± 0.2 GeV/c^2
M_H	121.9 ± 1.1 GeV/c^2	118.9 ± 0.2 GeV/c^2	120.2 ± 0.3 GeV/c^2	13.5 ± 1.1 GeV/c^2	14.7 ± 0.2 GeV/c^2	14.3 ± 0.2 GeV/c^2
M_W	83.8 ± 0.8 GeV/c^2	82.5 ± 0.2 GeV/c^2	83.9 ± 0.2 GeV/c^2	10.9 ± 0.2 GeV/c^2	12.6 ± 0.2 GeV/c^2	10.8 ± 0.2 GeV/c^2
M_t	173.8 ± 1.3 GeV/c^2	172.8 ± 0.3 GeV/c^2	175.9 ± 0.4 GeV/c^2	16.0 ± 1.0 GeV/c^2	18.9 ± 0.3 GeV/c^2	17.2 ± 0.3 GeV/c^2

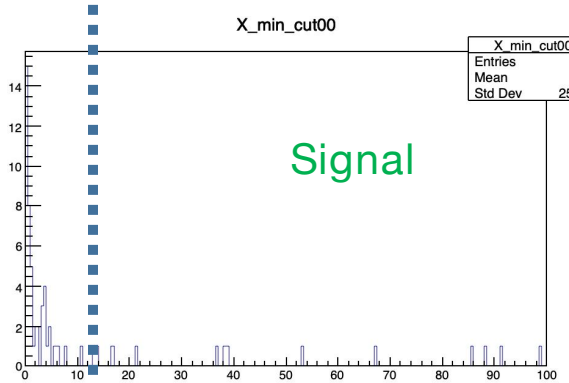
from AN-21-140

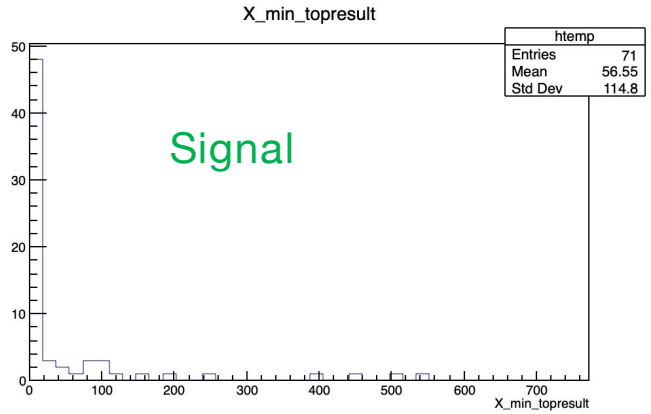
Chi2 Sorting Algorithm for Jets

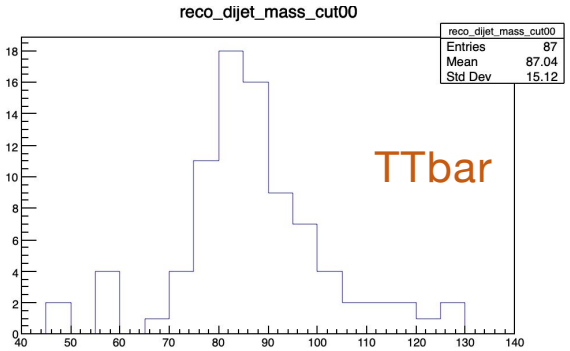
- The following plots are after these cuts: basic cuts && deltaR(mu+, mu-) < 1 && mu pair mass∉[80, 100] && mu pair pt > 140 && HT > 300 && deltaR(mu+, loose b jet) > 1.5 && deltaR(mu+, loose b jet) > 1.5
  - Add cut: Chi2 < 15 (maybe tighter?)

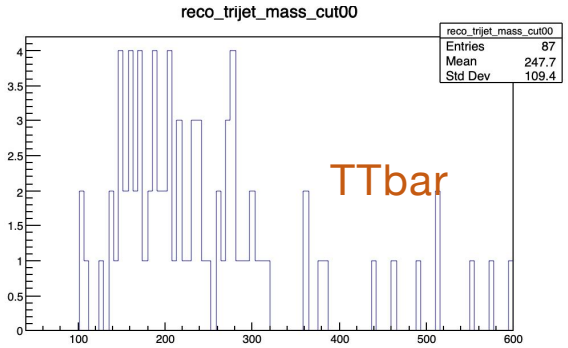


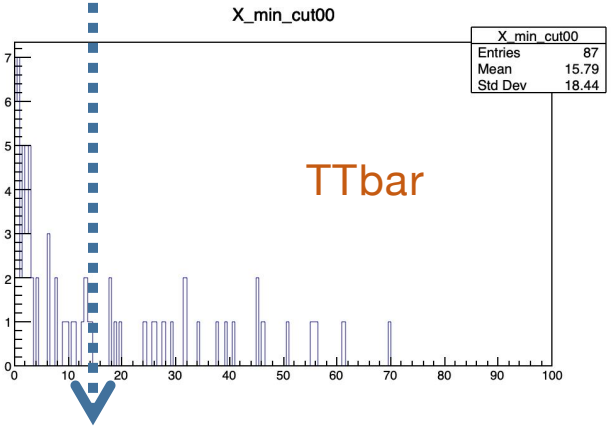


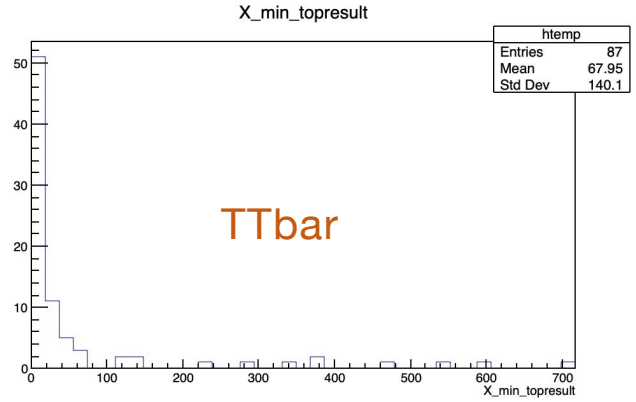






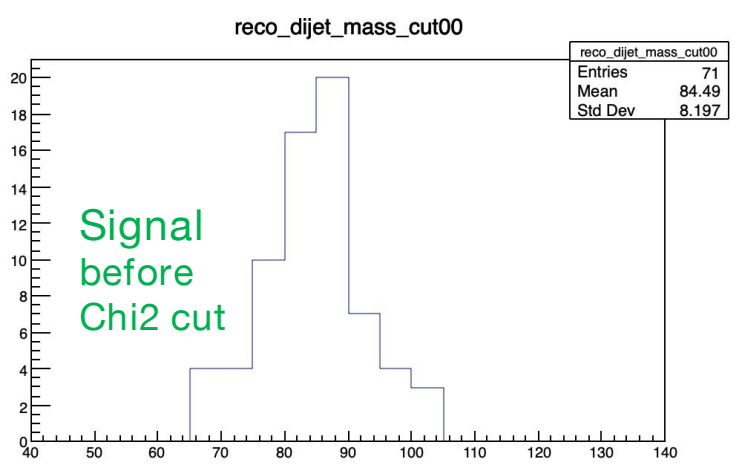


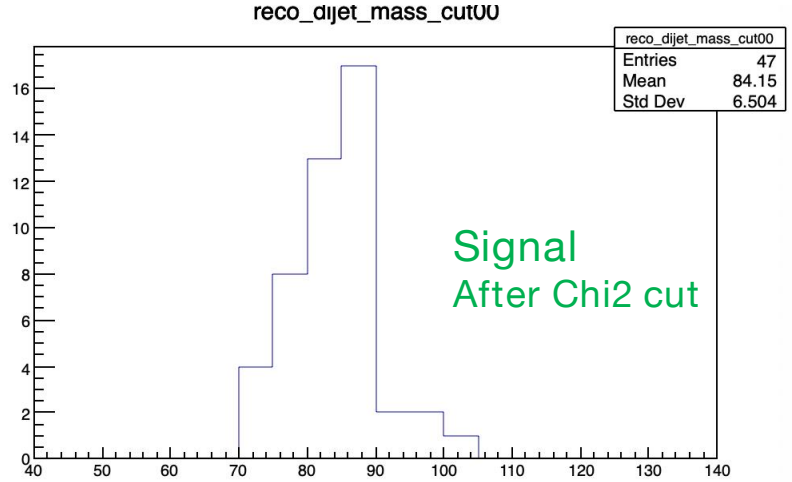


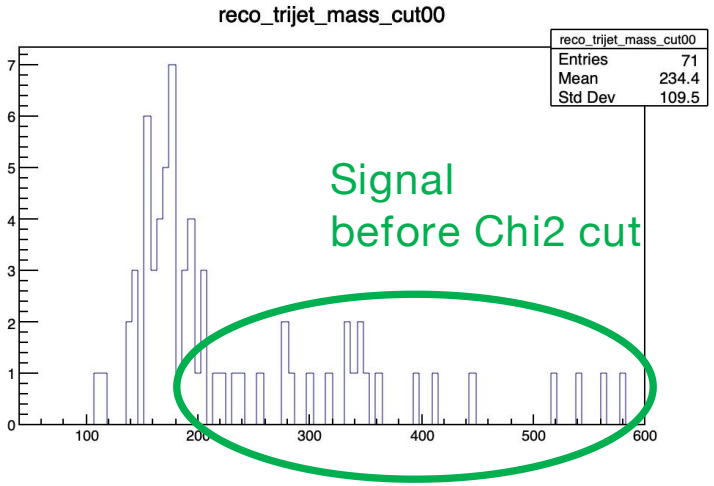


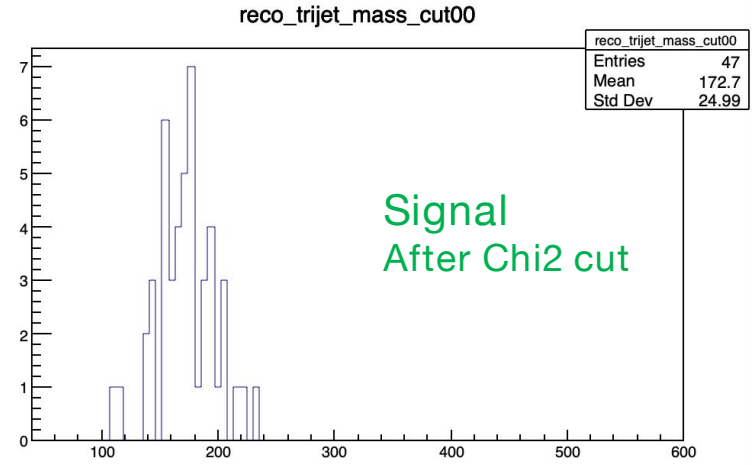
Chi2 Sorting Algorithm for Jets

- Before and after Chi2 < 15
  - Improvement of top reconstruction









Muon Pair Strategy

- Cuts related to muon pairs: N_goodMuon >=2 && OS && deltaR (mu+, mu-) < 1 && mu pair mass∉[80, 100] && mu pair pt > 140
- To select muon pair candidates, loop over all good (Tight ID && Pt(mu) > 20GeV) muons and get all OS pairs
- Then apply muon pair cuts to the OS pair candidates
- For each event, require at least 1 qualified muon pair

```
// not real code!
for(i = 0; i < number_of_good_muons; i++){
        for(j = i + 1; j < number_of_good_muons; j++){
                if(charge_of_muon[i] + charge_of_muon[j] == 0){
                        muon_pair_candidate = good_muon[i] + good_muon[j];
                }
        }
}
```

- Compare with another strategy: N_goodMuon ==2 && Charge of mu1 + charge of mu2 == 0 && deltaR (mu+, mu-) < 1 && mu pair mass∉[80, 100] && mu pair pt > 140
  - No big difference according to MC study, both are ok

	TT		Signal	
N_goodMuon >=2 (Loop)	310.42	-0.5%	1.62	-2%
N_goodMuon ==2 (No Loop)	308.67		1.58	

To do list

- Refine cut strategy
  - Too many signal events are removed
  - Make cut flow table
  - Remove/ Optimize/loosen some cuts

	TTbar	Signal	TTZ	TTH
Events number after all cuts	308	1.58	33	10

- 25th July to 5th August will be my summer break!
  - See you after the break!